SciMedCentral

Annals of Sports Medicine and Research

Short Communication

Heart Rate Variability Biofeedback in ACL Rehabilitation to Optimise Psychological Readiness for Successful Outcomes in Returning to Sport

Daniel Donnelly[1]* and Emmanouil Georgiadis[2]

[1]*Nuffield Health, UK*

[2]*School of Social Sciences and Humanities, University of Suffolk, UK*

***Corresponding author**
Dan Donnelly, Nuffield Health, UK

Submitted: 29 December 2023

Accepted: 27 January 2024

Published: 29 January 2024

ISSN: 2379-0571

Keywords
- Anterior cruciate ligament
- ACL reconstruction
- ACL- Return to Sport after Injury
- Heart rate variability biofeedback
- Tampa Scale of Kinesiophobia

Abstract

The article briefly introduces the rationale behind ACL-Reconstruction (ACL-R) and discusses why commonly applied biomechanical approaches should be balanced with psychotherapeutic methods due to the relationship between poor psychological outcome measures and return to play. ACL-R poses significant and unique challenges for successful recovery and return to play for many athletes due to various psychological, cognitive, and social challenges. As a result, the article conceptualises a solution in the form of using heart rate variability biofeedback (HRVB) as a complementary technique to psychological interventions to improve outcomes in the RSI-11 and TSK-11 and encourages research in this area to confirm the positive impact of HRVB on the successful return to play in this population.

ABBREVIATIONS

ACL: Anterior Cruciate Ligament; ACL-R: ACL Reconstruction; ACL- Return to Sport after Injury (RSI); TSK-11: Tampa Scale of Kinesiophobia; HRVB: Heart Rate Variability Biofeedback; ITB: Iliotibial band; MSK: Musculoskeletal; MDT: Multidisciplinary Team; HRV: Heart Rate Variability

INTRODUCTION

Anterior cruciate ligament (ACL) injury is one of the most common procedures in sports medicine [1]. This article will briefly outline the rationale for ACL reconstruction,while discussing potential neurophysiological mechanisms that contribute to worsened psychological state and return to play outcomes. The article will then propose a solution for Physiotherapist's to improve psychological outcomes in the form of heart rate variability biofeedback (HRVB) to ensure that Physiotherapy interventions concomitantly address functional and psychological outcomes in rehabilitation after ACL reconstruction (ACL-R).

The rationale for ACL-R is usually based on biomechanical reasoning. The surgical procedure usually involves taking an autograft from the individual's hamstring, patella or adductor tendon to replace the damaged ligament, and is increasingly performed alongside Iliotibial band (ITB) tenodesis to further reduce recurrent ACL rupture [1]. The tendinous tissue is then proposed to go through healing, proliferation and maturation [2] so it is able to perform its functional role of providing stability against anterior tibial translation and internal rotation [3].

The rehabilitation process usually results in excellent outcomes in knee stability and muscle strength following a well-designed rehabilitation process [4]. Despite excellent physical objective outcomes, there appears to be a disconnect between registering good physical outcomes and successful return to sport. Several meta-analyses discovered that compromised psychological readiness increases the risk of an unsuccessful return to sport [5-8]. Moreover, an observational study (16) found that greater self- reported fear reported in the Tampa Scale of Kinesiophobia (TSK-11) correlated with lower single leg hop performance, quadricep strength and increased risk of a re-rupture within 24 months. The importance of positive psychological outcomes are further supported by (9;10) who found that better ACL- Return to Sport after Injury (RSI) outcomes are strongly and significantly associated with return to sport. Faleide and colleagues (33) also found that their cohort of active sporting participants were less likely to return to sport with a low score on the ACL-RSI scale [11]; scores 0 to 100; low responses > 47), and that this was more predictive than functional outcomes.

Recent evidence supports the notion that functional neuroplastic changes occur in people with ACL injury [12]. Research shows a link between ruptured ACL and greater

anterior cingulate gyrus activity levels which helps to explain increased emotional tone and subsequent fear perception can increase sensitivity and pain intensities when exposed to passive visualisation tasks that evoked their fear of harm in other musculoskeletal (MSK) conditions [14]. Therefore, clinicians should view ACL injuries not only as a musculoskeletal pathology, but also as a neural lesion with neurocognitive and neurophysiological aspects [15]. This could help to explain kinesiophobia and clinical outcomes discovered by Paterno and colleagues [16] who found that greater self-reported fear and lower TSK-11 scores worsened functional outcomes and return to sport.

While protocols such as the Melbourne protocol offer a comprehensive framework to bolster outcomes post ACL-R, it is reasonable to state that Physiotherapists spend less time addressing techniques to tackle the two psychological outcome measures included in the protocol. The previously mentioned TSK-11 and ACL-RSI scales measure an individual's subjective psychological state which relates to catastrophizing and kinesiophobia status. While this shows a clear understanding of psychological involvement and the importance of patient reported outcome measures, there is an absence of psychological strategies within Physiotherapy ACL protocols to the authors knowledge, which means that Physiotherapists might be ill equipped to address associated psychological or emotional fears. This is compounded by research which indicates that many Physiotherapists believe that they lack the skills to induce psychological change [17].

While professional outfits have the luxury of a psychologist within their multidisciplinary team (MDT), many semi-professional and amateur athletes do not have access to such professionals. In the absence of a qualified psychologist, and given that Physiotherapists usually have the most contact time with athletes post-operatively, it seems reasonable to propose feasible psychotherapeutic strategies that can be used within the clinical environment to complement conventional rehabilitation [17].

Current literature seems to suggest an abundance of reasons for the offer of psychological support to athletes undergoing ACL-R rehabilitation, with negative thinking patterns contributing to anxiety, fear and depressive symptoms during this period acting as a major obstacle towards the quest for a successful return to sporting action. Presented with such a challenge, the solution seems to relate to an effective application of cognitive restructure methods while retaining personal control, competence, and relatedness, with the overarching goal to achieve adaptive behavioural responses towards a successful return to competitions [18-20]. Within such psychological support, certain techniques seem to help the successful return to play, with goal setting, relaxation, imagery, positive self-talk, adaptive modelling and counselling showing increased effectiveness and predominant position as mental techniques/ procedures of choice [21].

One solution that can significantly support the effectiveness of these psychological techniques and strategies, is in the form of heart rate variability biofeedback (HRVB). HRVB is a method to increase Heart Rate Variability (HRV). During HRVB individuals learn to breath slowly, at a rate close to 6 breaths per minute that induces various positive results in the autonomic nervous system via two reflexive mechanisms, the Respiratory Sinus Arrhythmia, and the Baroreflex heart receptors [22]. Such slow breathing induces the activation of the parasympathetic system -mediated by the Vagus Nerve- creating feelings of relaxation and calmness. Additionally, HRVB has been linked to significant positive effects on cognitive, social and physiological components of the human system, with a recent meta-analysis supporting modest by highly significant positive effects on a large array of physical, cognitive, behavioural and cognitive conditions [23].

Associating the reality of athletes recovering from ACL-R to studies specifically assessing important components of mental health, improved HRV outcomes via HRVB are associated with better emotional wellbeing [24], lower levels of worry [25], lower anxiety [26] and better regulation of emotions [27]. While no direct evidence exists which examines the relationship between HRVB interventions, ACL-RSI and TSK-11 to the authors knowledge, there is research which demonstrates a link between compromised HRV and other musculoskeletal pathologies including neck pain [28]. Interestingly, there is evidence showing that improved HRV in response to HRVB improves symptoms in chronic neck pain [28]. Catastrophizing and kinesiophobia are common terms associated with neck pain [29] which parallels the language used in the ACL-RSI and TSK-11 scales that includes nervousness, fear and feeling afraid. A more germane article showed mixed results in that a medium to large effect size was found in the HRVB group versus control in a group of 28 athletes for improvements in catastrophizing and psychological distress, although the results were non-significant [30]. Despite this, HRVB could offer a solution to address catastrophizing and kinesiophobia, as HRVB has been shown to alter functional brain connectivity in emotional and executive regions of the brain [31].

HRVB can be used alongside other psychological methods to address the factors mentioned throughout this article since this method can be easily learned, increasing the effects of interventions aiming towards improved psychosocial functioning. Based on the results of [23] meta-analysis, HRVB is one of the best additions to the skill set of practitioners working in the settings of behavioural medicine, mental health, and sport psychology. A recent meta-analysis also confirmed the significant positive effects of HRVB on improving depressive symptoms in various psychophysiology conditions showing its potential to improve psychological well-being and quality of life indices for populations in need [32,33]. Hence, future research can assess the effects of interventions combining HRVB with other psychological techniques such as cognitive restructuring, psychosocial interventions and counselling, to establish whether it could improve ACL- RSI and TSK-11 scores and subsequent successful return to play.

SUMMARY

ACL-R poses significant and unique challenges for successful

recovery and return to play for a large number of athletes due to various psychological, cognitive, and social challenges. This well-explored phenomenon requires the design of a carefully crafted psychological intervention which requires additional resources and expertise. In this short perspective paper, we propose the addition of HRVB as a complementary technique to psychological interventions taking place during the rehabilitation period from ACL-R. Recent studies and meta-analytic evaluations support the efficiency of HRVB to reduce negative psychological responses in various psychophysiology conditions, supporting mental health and well-being of populations in need. Future studies need to confirm the positive impact of HRVB on the successful return to play both as an adjunct to existing psychological interventions and as a sole component of interventions aiming for positive mental, emotional and social responses during ACL-R rehabilitation and return to play stages.

REFERENCES

1. Porter M, Shadbolt B. Modified iliotibial band tenodesis versus lateral extracapsular tenodesis, to augment anterior cruciate ligament reconstruction: a 2-year randomized controlled trial. ANZ J Surg. 2022; 92: 2247-2253.
2. Yao S, Fu BSC, Yung PSH. Graft healing after anterior cruciate ligament reconstruction (ACLR). Asia Pac J Sports Med Arthrosc Rehabil Technol. 2021; 11: 8-15.
3. Domnick C, Raschke MJ, Herbort M. Biomechanics of the anterior cruciate ligament: Physiology, rupture and reconstruction techniques. World J Orthop. 2016; 7: 82-93.
4. Ardern CL, Webster KE, Taylor NF, Feller JA. Return to the preinjury level of competitive sport after anterior cruciate ligament reconstruction surgery: Two-thirds of patients have not returned by 12 months after surgery. Am J Sports Med. 2011; 39: 538–543.
5. Xiao M, Van Niekerk M, Trivedi NN, Hwang CE, Sherman SL, et al. Patients Who Return to Sport After Primary Anterior Cruciate Ligament Reconstruction Have Significantly Higher Psychological Readiness: A Systematic Review and Meta-analysis of 3744 Patients. Am J Sports Med. 2023; 51: 2774-2783.
6. Longo UG, De Salvatore S, D'Orrico F, Bella M, Corradini A, Rizello G, et al. The impact of Psychological Factors on Return to Sports after Anterior Cruciate Ligament Reconstruction: A systematic Review. Osteology. 2023; 3: 78-93.
7. Forsdyke D, Smith A, Jones M, Gledhill A. Psychosocial factors associated with outcomes of sports injury rehabilitation in competitive athletes: A mixed studies systematic review Br J Sports Med. 2016; 50: 537-544.
8. Ardern CL, Taylor NF, Feller JA, Webster KE. Fifty five percent return to competitive sport following anterior cruciate ligament reconstruction surgery: An updated systematic review and meta-analysis including aspects of physical functioning and contextual factors. Br J Sports Med . 2014; 48: 1543-1552.
9. Paterno MV, Flynn K, Thomas S, Schmitt LC. Self-Reported Fear Predicts Functional Performance and Second ACL Injury After ACL Reconstruction and Return to Sport: A Pilot Study. Sports Health. 2018; 10: 228-233.
10. Sadeqi M, Klouche S, Bohu Y, Herman S, Lefevre N, Gerometta A . Progression of the Psychological ACL-RSI Score and Return to Sport After Anterior Cruciate Ligament Reconstruction: A Prospective 2-Year Follow-up Study From the French Prospective Anterior Cruciate Ligament Reconstruction Cohort Study (FAST). Orthop J Sports Med. 2018; 6: 1-7.
11. Webster KE, Feller JA, Lambros C. Development and preliminary validation of a scale to measure the psychological impact of returning to sport following anterior cruciate ligament reconstruction surgery. Phys Ther Sport. 2008; 9: 9-15.
12. Neto T, Sayer T, Theisen D, Mierau A. Functional Brain Plasticity Associated with ACL Injury: A Scoping Review of Current Evidence. Neural Plast. 2019; 27: 3480512.
13. Lindquist KA, Wager TD, Kober H, Bliss-Moreau E, Barrett LF. The brain basis of emotion: a meta-analytic review. Behav Brain Sci. 2012; 35: 121–43.
14. Bandeira PM, Pâmela M, Reis FJJ, Fernanda M, Anna C, Orlando F, et al. Heart Rate Variability and Pain Sensitivity in Chronic Low Back Pain Patients Exposed to Passive Viewing of Photographs of Daily Activities. Clin J Pain. 2021; 37: 591-597.
15. Piskin D, Benjaminse A, Dimitrakis P, Gokeler A. Neurocognitive and Neurophysiological Functions Related to ACL Injury: A Framework for Neurocognitive Approaches in Rehabilitation and Return-to-Sports Tests. Sports Health. 2022; 14: 549-555.
16. Paterno MV, Flynn K, Thomas S, Schmitt LC. Self-Reported Fear Predicts Functional Performance and Second ACL Injury After ACL Reconstruction and Return to Sport: A Pilot Study. Sports Health. 2018; 10: 228-233.
17. Piussi R, Krupic F, Senorski C, Svantesson E, Sundermo D, et al. Psychological impairments after ACL injury – Do we know what we are addressing? Experiences from sports physicalthera. Scand J Med Sci Sports. 2021; 31: 1508-1517.
18. Ardern CL, Taylor NF, Feller JA, Webster KE. Return-to-sport outcomes at 2 to 7 years after anterior cruciate ligament reconstruction surgery. Am J Sports Med. 2012; 40: 41-8.
19. Ardern CL, Hooper N, O'Halloran P, Webster KE, Kvist J. A Psychological Support Intervention to Help Injured Athletes "Get Back in the Game": Design and Development Study. JMIR Form Res. 2022; 6: e28851.
20. Gervis M, Pickford H, Hau T, Fruth M. A review of the psychological support mechanisms available for long-term injured footballers in the UK throughout their rehabilitation. Sci Med Footb. 2020; 4: 22-29.
21. Gennarelli SM, Brown SM, Mulcahey MK. Psychosocial interventions help facilitate recovery following musculoskeletal sports injuries: a systematic review. Phys Sportsmed. 2020; 48: 370-377.
22. Lehrer PM, Vaschillo E, Vaschillo B, Lu SE, Eckberg DL, et al. Heart rate variability biofeedback increases baroreflex gain and peak expiratory flow. Psychosom. Med. 2003; 65: 796-805.
23. Lehrer P, Kaur K, Sharma A, Shah K, Huseby R, Bhavsar J, et al. Heart rate variability biofeedback improves emotional and physical health and performance: a systematic review and meta analysis. Appl Psychophysiol Biofeedback. 2020; 45: 109-129.
24. Beauchaine TP, Thayer JF. Heart rate variability as a transdiagnostic biomarker of psychopathology. Int J Psychophysiol. 2015; 98: 338–350.
25. Ottaviani C, Thayer JF,Verkuil B, Lonigro A, Medea B, Couyoumdjian A, Brosschot JF Physiological concomitants of perseverative cognition: A systematic review and meta-analysis. Psychol Bull. 2016; 142: 231–259.
26. Chalmers JA, Quintana DS, Abbott MJ, Kemp AH. Anxiety disorders are associated with reduced heart rate variability: a meta-analysis. Front. Psychiatry. 2014; 5: 1-11.
27. Appelhans BM, Luecken LJ. Heart rate variability as an index of regulated emotional responding. Rev Gen Psychol. 2006; 10: 229.

28. Hallman DM, Olsson EMG, Sche´ele BV, Melin L, Eugene L. Effects of Heart Rate Variability Biofeedback in Subjects with Stress-Related Chronic Neck Pain: A Pilot Study. Appl Psychophysiol Biofeedback. 2011; 36: 71-80.

29. Yamashita Y, Kogo H, Nishigami T, Higashi T. Are catastrophizing and kinesiophobia associated with disability in patients with chronic neck pain ? Japanese Journal of Health Promotion and Physical Therapy. 2017; 8: 101-106.

30. Rollo S, Tracey J, Prapavessis H. Effects of a Heart Rate Variability Biofeedback Intervention on Athletes Psychological Responses Following Injury: A Pi. Lot study. Int J Sports Exerc Med. 2017; 3: 1-14.

31. Schumann A, De la Cruz F, Köhler S, Brotte L, Bär KJ. The Influence of Heart Rate Variability Biofeedback on Cardiac Regulation and Functional Brain Connectivity. Front Neurosci. 2021; 29: 691988.

32. Pizzoli SFM, Marzorati C, Gatti D, Monzan D, Mazzocco K, Pravettoni G. A meta- analysis on heart rate variability biofeedback and depressive symptoms. Nature. 2021; 11: 1-10.

33. Faleide AGH, Inderhaug E, Vervaat W, Breivik K, Bogen BE, Mo IF, et al. Anterior cruciate ligament-return to sport after injury scale: validation of the Norwegian language version. Knee Surg Sports Traumatol Arthrosc. 2020; 28: 2634-2643.